

The next question is, what multiples of these units we should take to make the practical units. In accordance with your request I give my ideas on the subject, premising, however, that I think there is no finality in things of this sort.

First, if we let the rational practical units be the same multiples of the "absolute" rational units as the present practical units are of *their* absolute progenitors, then we would have (if we adopt the centimetre, gramme, and second, and the convention that $\mu = 1$ in ether)

$$\begin{aligned}[R_r] \times 10^9 &= \text{new ohm} = x^2 \text{ times old.} \\ [L_r] \times 10^9 &= \text{new mac} = x^2 \text{ ,, ,,} \\ [S_r] \times 10^{-9} &= \text{new farad} = x^{-2} \text{ ,, ,,} \\ [C_r] \times 10^{-1} &= \text{new amp} = x^{-1} \text{ ,, ,,} \\ [V_r] \times 10^8 &= \text{new volt} = x \text{ ,, ,,} \\ 10^7 \text{ ergs} &= \text{new joule} = \text{old joule.} \\ 10^7 \text{ ergs per sec} &= \text{new watt} = \text{old watt.}\end{aligned}$$

I do not, however, think it at all desirable that the new units should follow on the same rules as the old, and consider that the following system is preferable:—

$$\begin{aligned}[R_r] \times 10^8 &= \text{new ohm} = \frac{x^2}{10} \times \text{old ohm.} \\ [L_r] \times 10^8 &= \text{new mac} = \frac{x^2}{10} \times \text{old mac.} \\ [S_r] \times 10^{-8} &= \text{new farad} = \frac{10}{x^2} \times \text{old farad.} \\ [C_r] \times 1 &= \text{new amp} = \frac{10}{x} \times \text{old amp.} \\ [V_r] \times 10^8 &= \text{new volt} = x \times \text{old volt.} \\ 10^8 \text{ ergs} &= \text{new joule} = 10 \times \text{old joule.} \\ 10^8 \text{ ergs per sec.} &= \text{new watt} = 10 \times \text{old watt.}\end{aligned}$$

It will be observed that this set of practical units makes the ohm, mac, amp, volt, and the unit of elastance, or reciprocal of permittance, all larger than the old ones, but not greatly larger, the multiplier varying roughly from $1\frac{1}{4}$ to $3\frac{1}{2}$.

What, however, I attach particular importance to is the use of one power of 10 only, viz. 10^8 , in passing from the absolute to the practical units; instead of, as in the common system, no less than four powers, 10^1 , 10^7 , 10^8 , and 10^9 . I regard this peculiarity of the common system as a needless and (in my experience) very vexatious complication. In the 10^8 system I have described, this is done away with, and still the practical electrical units keep pace fairly with the old ones. The multiplication of the old joule and watt by 10 is, of course, a necessary accompaniment. I do not see any objection to the change. Though not important, it seems rather an improvement. (But transformations of units are so treacherous, that I should wish the whole of the above to be narrowly scrutinized.)

It is suggested to make 10^9 the multiplier throughout, and the results are:—

$$\begin{aligned}[R_r] \times 10^9 &= \text{new ohm} = x^2 \times \text{old ohm.} \\ [L_r] \times 10^9 &= \text{new mac} = x^2 \times \text{old mac.} \\ [S_r] \times 10^{-9} &= \text{new farad} = x^{-2} \times \text{old farad.} \\ [C_r] \times 1 &= \text{new amp} = \frac{10}{x} \times \text{old amp.} \\ [V_r] \times 10^9 &= \text{new volt} = 10x \times \text{old volt.} \\ 10^9 \text{ ergs} &= \text{new joule} = 10^2 \times \text{old joule.} \\ 10^9 \text{ ergs p. sec.} &= \text{new watt} = 10^2 \times \text{old watt.}\end{aligned}$$

But I think this system makes the ohm inconveniently big, and has some other objections. But I do not want to dogmatize in these matters of detail. Two things I would emphasize:—First, rationalize the units. Next, employ a single multiplier, as, for example, 10^8 .

OLIVER HEAVISIDE.

P.S.—Heaven preserve us from dynamics based on the Act of Parliament!

Neutral Point in the Pendulum.

In the theory of the pendulum the position of the neutral point of support is a matter of practical importance, which is, nevertheless, quite disregarded.

Taking a rigid uniform bar as the simplest case, there are

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four points of support from which its vibrations are equal, the two ends and the two respective centres of oscillation. But there are two symmetric points, situated between either end and the centre of oscillation nearest to that end, from which points of suspension the rate of vibration is most rapid. Hence, when suspended from these points, a change in the position of the point of support produces a minimum difference in the rate of vibration. Or, in practical terms, there is a great advantage in having a small amount of overhead weight above the support, as then, if the support approach the bob (owing to changes in elasticity of the spring, or of the knife edges), and so increase the number of vibrations, it recedes from the top weight, and so diminishes the vibrations to a corresponding amount, and *vice versa*.

This neutral point of support seems to have been overlooked in the main pendulum researches, as it was what had to be avoided rather than sought in the determination of the length, which was then the main interest. Probably some one has already noticed such an elementary property; but it is of so much value in minimizing sources of error that it is worth some attention.

Bromley, Kent.

W. M. FLINDERS PETRIE.

Induction and Deduction.

CAN we determine the precise relation between Induction and Deduction? Both are said to be a species of Inference. *Deduction* is, no doubt, Mediate Inference. Is *Induction* Mediate or Immediate Inference? If Immediate it must be of the form:

$$\begin{aligned}\text{This X is Y (or these X's are Y's)} &\dots\dots (1) \\ \therefore \text{All X's are Y's} &\dots\dots (2)\end{aligned}$$

But such "inference" as this is not illative; (1) can furnish only a suggestion, not by any means a justification, of (2).

Still it is true that if, *e.g.* I have proved that the angles at the base of an isosceles triangle are equal to each other, I henceforth believe and assert unhesitatingly, that *all* isosceles triangles have the angles at the base equal. *How* do I justify such a conclusion of an universal from a particular? In this way, I think:—Every nameable or cogitable object is an identity in diversity—that is, it is itself, it is *something*, and it has a plurality of characteristics. This principle is involved in the assertion of any statement of the form *A is B*, and it seems moreover to be, in itself, evident on reflection. Further (as Bacon surmised), every property (or group of properties) has a "form," some invariable and inevitable coexistent. In other words, there is uniformity of coexistence as well as of causation in nature. In the case of any one isosceles triangle, I have *seen* the connection of interdependence that there is between the characteristics of "having equal sides," and "having the angles at the base equal;" I have perceived it to be self-evident that the one property involves the other. Hence, my whole argument might run thus:—

Every characteristic is invariably accompanied by some other characteristic;

Equality of sides in a triangle is a characteristic;

$\therefore$ Equality of sides in a triangle is invariably accompanied by some other characteristic.

Again:—

Equality of angles at the base is a characteristic which is (self-evidently) inseparable from equality of sides in one [this particular] case;

What is inseparable from equality of sides in one case is inseparable in all cases;

$\therefore$ Equality of angles at the base is inseparable from equality of sides in all cases—

That is, *all* isosceles triangles have the angles at the base equal.

What we rely on here is Interdependence of characteristics and Uniformity of that interdependence; *i.e.* we rely on a principle of coexistence or coinherence, parallel to Mill's "Law of Causation"; and this is a principle which we find to be a necessary condition of what we accept as strictly self-evident propositions. The assertion with which we conclude in the above generalization, is an assertion of uniformity of interdependence between certain specified characteristics.

Again, if I administer a certain amount of arsenic to a healthy animal, and it dies, and I hence conclude that arsenic is a cause

of death, I argue thus:—Since every event (= change of attributes in subjects) has a cause, the death in question had a cause; the only precedent event that was relevant, was the administration of arsenic, therefore the arsenic was in this case the cause of death (this last result is obtained by the Method of Difference—by it we prove cause—*i.e.* interdependence of successive events). But (by the principle of uniformity) if arsenic is on one occasion cause of death, it is always cause of death; therefore arsenic is always a cause of death.

It will be observed that in this second induction, though not in the first, we make use of one of Mill's "Inductive Methods." The function of these Methods is to prove interdependence between phenomena—whether it be an interdependence of concomitance or of causation. In the case of the Method of Difference we proceed on the assumption that if the introduction of A is followed by the appearance of C, or the removal of A by the disappearance of C, then A and C are causally interdependent. In the Method of Agreement we proceed on the assumption that if A is never found without C, A has a connection of interdependence with C.

We do not use, and do not need, these Methods in mathematical generalizations, because there we *see* the interdependence upon which generalization to unknown cases is based; it is this actual apprehension of interdependence that both makes the methods unnecessary and gives mathematical generalizations the peculiar certainty which is generally attributed to them. In the case above cited, for instance, we *see* that equality of angles at the base is self-evidently and necessarily bound up with equality of sides in a triangle. We do *not* see that there is a self-evident interdependence between the obvious properties of arsenic and poisonousness.

A further interesting point is that our power of predicting that one event, A, will be *followed* by another event, C, seems to depend wholly upon *coexistence* of attributes in the subjects concerned. If we have seen one animal dosed with arsenic and subsequently die, and hence conclude that another animal called by the same name, and dosed with an equal amount of arsenic, will die, is not our inference based upon the assumption of a certain constant coinherence of attributes, both in the animal and in the poison—a coinherence of such a kind that when the two subjects are so collocated as to act upon each other, a result similar to that produced in the first case will be produced in the second also? If the properties of this arsenic are different from the other, or if the second animal, though looking like the first, has a different internal constitution, there is no reason why death should result. Hence, laws of succession in events seem to depend upon laws of coexistence of attributes in subjects.

Even those generally unquestioned axioms of logic, the Law of Contradiction and the Law of Excluded Middle, might be appealed to (if it were necessary) in support of the Principle of Interdependence—for the Law of Excluded Middle intimates a thoroughgoing connection (positive or negative) between all nameable things; and the Law of Contradiction asserts a certain definite amount of necessary interdependence of properties in every imaginable case—interdependence, namely, between the *presence of any characteristic and the absence of its negative*.

Looking at the whole process of inductive reasoning, it appears to be in the application of the "Methods" that the principles used approach nearest to the character of mere assumptions; and this is so only because of the difficulty of applying the Methods precisely—of being sure, *e.g.* in the case of the arsenic, that the administration of arsenic *was* the only new antecedent relevant to death.

It may just be noticed that in an argument by analogy we rely upon an interdependence which is inferred from the complexity or amount of interdependence already known or supposed.

If the above account of inductive reasoning is accepted, it appears that the connection between Induction and Deduction is very close—in fact, that the one distinctive feature of logical induction is the element of hypothesis or discovery—the supposition of a given connection—from which every Induction must set out.

Cambridge.

E. E. CONSTANCE JONES.

The Scale for Measurement of Gas Pressures.

I VENTURE to ask you to print the following suggestion. It is one likely enough to have been made before, but I do not remember having met with it.

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We generally measure gaseous pressures in millimetres of mercury, and 760 mm. is adopted as the standard pressure. It would certainly be more convenient if we expressed the measurement in degrees, the degree being of such magnitude that the standard pressure were 273°. All calculations involving change of P, T, and V to or from the standard conditions would be simplified in an obvious way. The equation $PV = RT$ would become $V = R$ at standard pressure and temperature. R being the same constant for all gases under all conditions, if V stand for the molecular volume, it would be convenient to remember it as identical with the well-known number expressing the standard volume of a gramme-molecule. 1°P would correspond to about 2.78 mm. or $\frac{1}{4}$ inch of mercury.

ORME MASSON.

The University of Melbourne, June 21.

Luminous Clouds.

BRIGHT luminous clouds were seen here on the night of Sunday the 24th inst., in the north and north-north-east, from 9.35 to 10.35 p.m. As usual they distinctly resembled *cirri*, having some definite upward curls. The actual *cirri*, which had after sunset been moving rapidly from east-south-east, now appeared dusky against the twilight glow. The filature of the upper or luminous *cirri* was, as appears to be usual, west and east, while that of the ordinary *cirri* was east-south-east and west-north-west.

These luminous clouds, although no doubt simply reflecting solar light, generally appear to the casual observer as incandescent or self-luminous.

They were seen from the summit of Ben Nevis all through the night of the 24th–25th, according to the report in the *Times*.

Lutterworth.

W. CLEMENT LEY.

Whirlwinds in the South Indian Ocean.

THE following account of whirlwinds met with in the South Indian Ocean at the end of last May, which has been supplied to the Meteorological Office by Messrs. Sandbach, Tinne & Co., of Liverpool, may be of interest to your readers.

ROBERT H. SCOTT,

July 22.

Secretary, Meteorological Office.

Extract from a Letter received from Capt. S. P. Hearn, Ship "Genista."

"At noon on May 26, lat. 42° 0' S., long. 99° 0' E., wind fresh from N.W.—weather very squally with rain, barometer steady at 29.82 in., thermometer 49° since midnight. A very heavy black squall with rain began to rise in the W. Barometer suddenly fell 0.1 in. As the squall neared the ship it arched up in the centre, showing a very bright blue sky at the back of it; the ends of the squall on either side were quite black and thick with rain. On its nearer approach to the ship I saw two immense whirlwinds, just a little on either side of the centre of the arch and coming direct for the ship, the sea under and near the whirls being carried around and up in great volumes. I thought at first they were two waterspouts forming, but I saw no descending column or clouds from above, as is seen when a waterspout is forming; when these whirls came to within two miles of the ship, the squall seemed to part in the centre of the arch—one half passing to the N.E., the other half to the S.E., one whirl following in rear of each part of the squall, and not where the clouds were heaviest. During the time of the separation of the arch we had the wind very unsteady from N.W. to S.W. There was only a fresh breeze with thick rain in that part of the squall that neared the ship; yet the squall was travelling along at a great rate, the whirls keeping in the rear till out of sight. I shortened sail to topsails as soon as I saw the squall rising. After it passed, the weather looked very fine, bright, and clear, but the sky was a windy one, being a very bright blue. By 3 p.m. the wind shifted to W., and barometer had fallen to 29.67 in., thermometer 48°. At 4 p.m. saw another whirl passing along to windward in the rear of a squall, the clouds above it being twined and twisted every way. During the whole night we had very heavy squalls, sometimes following one another very quick, with little wind between—direction W.S.W. At daylight the weather was much finer. After that, to lat. 40° 22' S., long. 125° E., I had very peculiar